Microbes as Biofertilizers: A General Overview

Biofertilizers are substances that contain living microorganisms which, when applied to seeds, plant surfaces, or soil, colonize the rhizosphere or the interior of the plant and promote growth by increasing the supply or availability of primary nutrients to the host plant. They add nutrients through natural processes, and do not negatively impact the environment. They are considered an environmentally friendly and sustainable alternative to chemical fertilizers.

Advantages of Biofertilizers

Biofertilizers offer several advantages over chemical fertilizers:

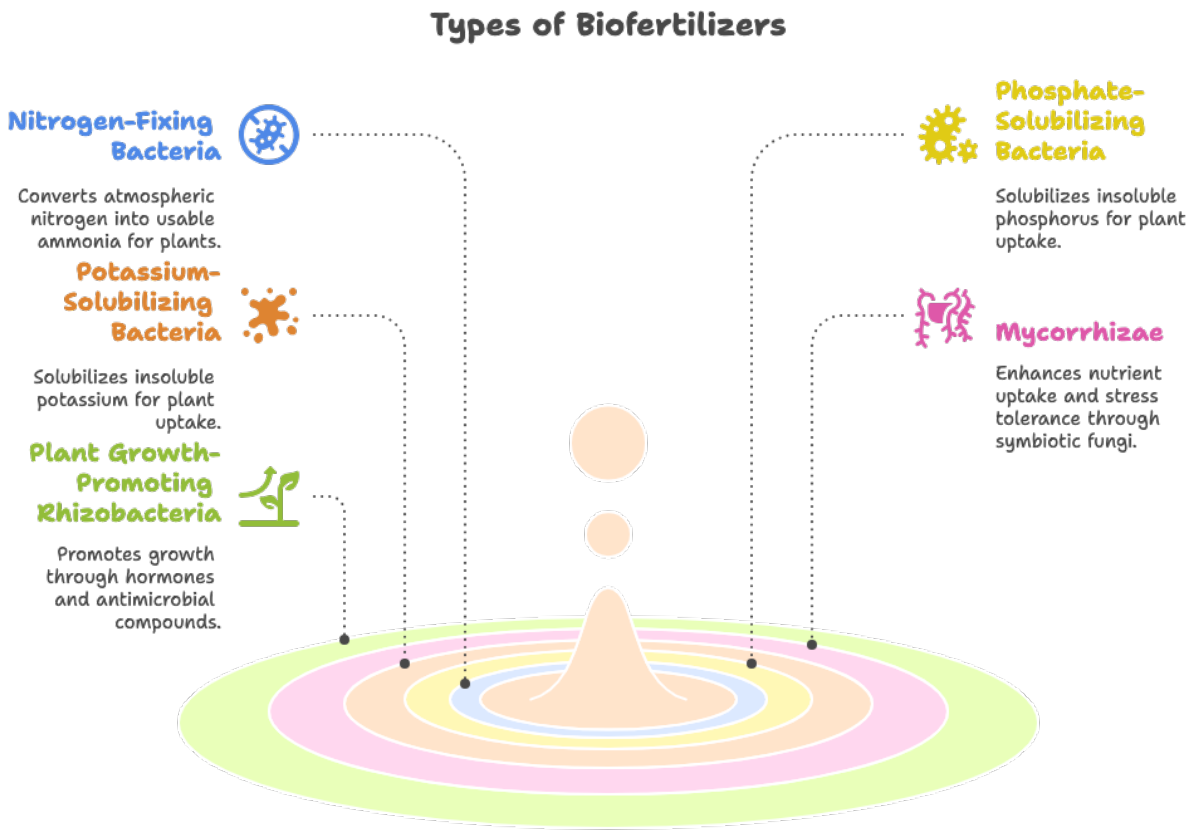
- **Environmental Friendliness:** Biofertilizers are eco-friendly and do not cause pollution of soil, water, or air.
- **Sustainability:** They promote sustainable agriculture by improving soil health and reducing the dependence on non-renewable resources.
- **Cost-Effectiveness:** Biofertilizers are generally cheaper than chemical fertilizers, making them accessible to small-scale farmers.
- **Improved Soil Health:** They improve soil structure, water-holding capacity, and nutrient availability.
- **Enhanced Plant Growth:** They promote plant growth by fixing atmospheric nitrogen, solubilizing phosphorus, and producing plant growth-promoting substances.
- **Reduced Disease Incidence:** Some biofertilizers can suppress plant diseases by producing antimicrobial compounds or inducing systemic resistance in plants.

Types of Microbes Used as Biofertilizers

Several types of microbes are used as biofertilizers, including:

- **Nitrogen-Fixing Bacteria:** These bacteria convert atmospheric nitrogen into ammonia, a form of nitrogen that plants can use. Examples include *Rhizobium*, *Azotobacter*, *Azospirillum*, and *Cyanobacteria*.
    - *Rhizobium* forms symbiotic relationships with leguminous plants, forming nodules on their roots where nitrogen fixation occurs.
    - *Azotobacter* and *Azospirillum* are free-living nitrogen-fixing bacteria that can colonize the rhizosphere of various plants.

    - *Cyanobacteria* (blue-green algae) are photosynthetic nitrogen-fixing bacteria that are commonly used in rice cultivation.
- **Phosphate-Solubilizing Bacteria (PSB):** These bacteria solubilize insoluble forms of phosphorus in the soil, making it available to plants. Examples include *Bacillus*, *Pseudomonas*, and *Aspergillus*.
- **Potassium-Solubilizing Bacteria (KSB):** These bacteria solubilize insoluble forms of potassium in the soil, making it available to plants. Examples include *Bacillus* and *Paenibacillus*.
- **Mycorrhizae:** These are symbiotic associations between fungi and plant roots. Mycorrhizae enhance nutrient uptake, especially phosphorus, and improve plant tolerance to drought and stress. There are two main types of mycorrhizae:
    - **Ectomycorrhizae:** Form a sheath around the root and penetrate between the root cells.
    - **Endomycorrhizae (Arbuscular Mycorrhizae):** Penetrate into the root cells, forming branched structures called arbuscules.
- **Plant Growth-Promoting Rhizobacteria (PGPR):** These bacteria colonize the rhizosphere and promote plant growth through various mechanisms, such as producing plant hormones, siderophores, and antimicrobial compounds. Examples include *Bacillus*, *Pseudomonas*, and *Streptomyces*.


Types of Biofertilizers
Nitrogen-Fixing Bacteria
Converts atmospheric nitrogen into usable ammonia for plants.
Potassium-Solubilizing Bacteria
Solubilizes insoluble potassium for plant uptake.
Plant Growth-Promoting Rhizobacteria
Promotes growth through hormones and antimicrobial compounds.
Phosphate-Solubilizing Bacteria
Solubilizes insoluble phosphorus for plant uptake.
Mycorrhizae
Enhances nutrient uptake and stress tolerance through symbiotic fungi.